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FOOD OF WEAKFISH IN COASTAL WATERS BETWEEN CAPE COD AND CAPE FEAR

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ABSTRACT

Stomach contents of 359 weakfish Cynoscion regalis were collected during Northeast Fisheries Center (NEFC) bottom trawl surveys during the spring, summer, and autumn of 1978 through 1980. The study area included the coastal waters between Cape Fear and Cape Cod with bottom depths greater or equal than 6 meters.

Weakfish fed primarily on schooling fish, except for juveniles (under 21 cm FL) which depended almost exclusively on mysid shrimp, namely Neomysis americana. Anchovies, especially bay anchovies, were the single most important fish prey of weakfish. Although menhaden and other clupeids were reported as a staple food of weakfish in nearshore and estuarine waters (ie. waters with depths less than 6 meters), these species were of little importance to weakfish in this study area. The results also showed weakfish to occassionally feed on decapod shrimp, crabs, squid, and rarely polychaete worms.

Dietary differences were evident according to the geographic area, season, and year. This variability seems related to fluctuations in distribution and abundance of both predator and prey. Weakfish fed primarily between dusk and dawn.

INTRODUCTION

The weakfish@ Cynoscion regalis, also known as squeteague or gray seatrout, is a member of the drum family Sciaenidae (Fig. 1). Weakfish occur primarily in estuarine and coastal waters off the eastern United States between Massachusetts and southern Florida, but are most abundant in waters north of North Carolina (Hildebrand and Schroeder 1928). Adult weakfish north of Cape Hatteras, move to inshore northerly waters with the advent of spring warming, and migrate south and offshore in the fall (Wilk 1976; Grosslein and Azarovitz 1982). Weakfish is equally important to both commercial and recreational fisheries along the coast (Murawski 1977; Mercer 1983).

Grosslein and Azarovitz (1982) indicated that most of the available information on weakfish is limited to estuarine and nearshore waters (herein defined to be less than 6 meters), although weakfish do occur farther offshore. The food of weakfish has been well documented for estuarine and nearshore waters of the eastern United States. Numerous estuarine investigations have shown weakfish to feed primarily on fish, while crustaceans, squid, and polychaetes were of lesser importance (Linton 1904; Smith 1907; Hildebrand and Schroeder 1928; Richards 1963). Bay anchovies (Anchova mitchilli), Atlantic menhaden (Brevoortia tyrannus), and other clupeids were reported as some of the major fish prey (Peck 1896; Smith 1907; Welsh and Breder 1923; Nichols and Breder 1927; Merriner 1975; Lascara 1981). Young weakfish are known to feed mainly on small crustaceans, especially mysid shimp, and undergo a dietary shift to fish as

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@Weakfish is the accepted common name given to Cynoscion regalis according to Robins et.al. (1980).

they grow (Eigenmann 1901; Hildebrand and Schroeder 1928; de Sylva et.al. 1962; Richards 1963; Thomas 1971; Stickney et.al. 1975; Chao 1976; Schwartz et.al. 1980). The mysid, Neomysis americana, is the most commonly reported species consumed by juveniles (de Sylva et.al. 1962; Thomas 1971; Stickney et.al. 1975; Schwartz et.al. 1980). Thomas (1971) and Schwartz et.al. (1980) also observed weakfish to be cannibalistic on its young in the estuarine nurseries.

Despite the information concerning the food habits of weakfish in nearshore and estuarine waters, little has been published for weakfish feeding in coastal waters (ie. waters greater or equal to 6 meters). Maurer and Bowman (1975) examined only 21 weakfish collected from coastal waters and found fish (mainly scup and Atlantic mackerel), squid, and the decapod shrimp, Dichelopandalus leptocerus as the major food.

This paper documents the food of weakfish occurring in the offshore portion of their distribution (ie. coastal waters having depths greater or equal to 6 meters) and examines the dietary variability according to predator length, season, year, geographic area, and time of day. Dietary differences of weakfish from estuarine and coastal waters are discussed, as well as their feeding strategy.

METHODS AND MATERIALS

COLLECTION

Samples were collected on bottom trawl surveys conducted by the Northeast Fisheries Center (NEFC) during the spring, summer, and autumn of 1978 through 1980 (Table 1). Standardized surveys occurred at stratified

random stations along the continental shelf between Cape Fear, North Carolina and Browns Bank, Nova Scotia (Grosslein 1974). A Yankee No. 36 or two-seam modified Yankee No. 41 otter trawl was towed for a 30 minute duration at a vessel speed of 3.5 knots and sampling continued around-the-clock (weather permitting).

Although weakfish have an estuarine and coastal distribution, the estuarine waters (less than 6 meters) could not be sampled due to the large size of the research vessel. Therefore, this study includes only the offshore portion of the weakfish's distribution. In this study, weakfish were caught in coastal waters between Cape Cod, Massachusetts and Cape Fear, North Carolina in depths ranging 7 to 120 m (only two occurred in depths greater than 29 m) (Fig. 2).

Weakfish were randomly sampled and measured by fork length to the nearest centimeter (cm FL). Fish showing signs of regurgitation (ie. food in buccal cavity) were not sampled. Stomachs from 359 weakfish were individually wrapped in gauze with a label denoting vessel, cruise number, station, species, length, sex, and maturity, and preserved in 3.7% formaldehyde. Small fish were preserved whole.

ANALYSIS

In the laboratory, preserved stomachs were individually opened, their contents emptied onto a 0.25 mm mesh sieve, and rinsed to remove formaldehyde without loss of food items. The stomach contents were sorted and identified to the lowest possible taxon. Each prey grouping was counted and weighed to the nearest 0.001 gram (g). Individual fish prey were recorded to the nearest millimeter by total length (mm TL). All

stomach content measurements are expressed as percentage of the total stomach content weight unless otherwise indicated. Feeding periodicity (Fig. 5) was examined in terms of percentage body weight (%BW = food wt(g) * 100 / fish wt(g)). In calculating the %BW, fish weight was derived from the length-weight equation, log10 weight(g) = -4.8765 + 2.9479 log10 length(mm) (Wilk 1979).

RESULTS

FOOD COMPOSITION

Food was found in 79% of the 359 weakfish stomachs examined (Table 1). Fish comprised three-fourths (74.8%) of the weakfish's diet by weight (Table 2). The most common fish prey was identified as anchovy (24.7%) with bay anchovy, Anchova mitchilli (20.3% and 139 identified) accounting for most of that family. Other fish prey identified were gulfstream flounder, Citharichthys artifrons (8.6%), sand lance, Ammodytes americanus (4.1%), striped anchovy, Anchoa hepsetus (2.8%), creville jack, Caranx hippos (2.4%), unidentified herring (2.2%), butterfish, Peprilus triacanthus (1.7%), and round herring, Etrumeus teres (1.7%). A young weakfish (120 mm TL) was found in the stomach of a 38 cm FL weakfish.

A variety of invertebrates were ingested by weakfish (Table 2). The crustacean component (15.0%) of their diet contained decapod shrimp (6.0%) and crabs (4.7%), mysid shrimp (3.4%), stomatopod shrimp (0.2%), and amphipods (0.2%). The predominant decapods were the shrimps, Dichelopandalus leptocerus (3.9%), and Crangon septemspinosus (1.5%), and the crab, Ovalipes ocellatus (4.4%). The largest number of any particular prey were mysid shrimp which totaled over 13 thousand animals for the total

stomach contents. They were identified as Neomysis americana (2.6%) and Mysidopsis bigelowi (0.7%). The squid (8.7%) eaten by weakfish was identified as Loligo sp. (5.4%) and Illex sp. (3.1%). Polychaetes (1.1%) were only incidental prey.

FOOD IN RELATION TO PREDATOR LENGTH

The type of prey identified within each length category showed that larger weakfish generally consumed larger prey. In general, prey size shifted from small crustaceans, particularly mysid shrimp, to larger fish as predator length increased (Table 3). Weakfish ranged from 7 to 75 cm FL with a mean of 28 cm FL. The smallest weakfish (7-10 cm FL) fed almost exclusively on mysids (89.0%) and its prey ranged in size from copepods (less than 2 mm TL) to decapod shrimp, C. septemspinosus (no larger than 55 mm TL). At longer predator lengths (11-20 cm FL), they fed on small (10-65 mm TL) fish (19.7%), but mysids (64.0%) remained the predominant prey. There was a pronounced shift in diet for the 21-30 cm length group (Fig. 3). These fish fed intensively on fish (77.2%) while mysids dropped to 6.1% of its diet. Mysids disappeared from the diet of weakfish over 50 cm in length. Larger decapods, namely crabs, were significant food only for weakfish over 60 cm FL.

The length of fish prey also increased with predator length (Fig. 4). Weakfish between 11 and 30 cm FL consumed fish prey ranging from 10 to 110 mm TL, while weakfish over 30 cm FL preyed upon fish ranging from 24 to 190 mm TL. Anchovies (20-124 mm TL) were an important food item for weakfish between 21-75 cm FL. The mean stomach content weight also increased with predator length.

FOOD ACCORDING TO GEOGRAPHIC AREA, SEASON, AND YEAR

The diet of weakfish fluctuated according to area, season, and year. (Table 4). Fish constituted more than two-thirds of the stomach contents for all areas and seasons with the exception of spring samples collected north of Cape Hatteras (NCH). In this season and area, crustaceans (70.8%) were more important than fish prey (28.8%) and the decapod shrimp, C. septemspinosus (67.4%) made up the bulk of the crustacean portion. Mysids, as well as C. septemspinosus, were more common in the NCH samples during spring and autumn, while few were present south of Cape Hatteras (SCH). Illex squid were found in the SCH samples during summer only and Loligo occurred in the NCH samples during fall only. Anchovies appeared to be more important during the summer and fall than spring in both areas. The mean stomach content weight within each geographic area also varied between seasons. The mean stomach content weight was largest during the spring and summer in the SCH samples, while the NCH samples were largest during the fall.

The food of weakfish varied annually (Table 5). Fish (58.4%) and mysids (33.4%) made up the bulk of the weakfish diet in 1978. In 1979, fish prey (78.0%) increased in importance, while anchovies (31.6%) accounted for almost a third of its diet. Mysids and anchovies were not identified in samples collected during 1980. The major prey identified during 1980 were decapod shrimps (14.6%) and C. artifrons (38.5%). An increase in the mean predator length by 7 cm per year must also be considered in the discussion.

FOOD ACCORDING TO TIME OF DAY

The mean stomach fullness (expressed as %BW) for weakfish fluctuated according to the time of day (Fig. 5). The lowest mean %BW was observed just before dusk (1300-1600 EST). The quantity of food consumed by weakfish began to increase around dusk, continued to increase during the night, peaked in early morning, and declined after dawn. The maximum %BW was observed during early morning hours (0100 through 0400). Weakfish fed primarily during the hours of minimal light intensities.

DISCUSSION

Analysis of the stomach contents of weakfish in coastal waters showed anchovies as the single most important prey with bay anchovy as the predominant species (Table 2). Anchovies were also reported as major food of weakfish in estuarine and nearshore waters (Welsh and Breder 1923; Hildebrand and Schroeder 1928; Thomas 1971; Merriner 1975; Stickney et. al. 1975; Chao 1976; Schwartz et. al. 1980; Lascara 1981). Merriner (1975) identified anchovies in 58% of the weakfish stomachs, while Chao (1976) found a 72% occurrence of bay anchovies in nearshore and estuarine waters. The heavy consumption of anchovies by weakfish implies that this species must be readily available as food. This is not surprising since Grosslein and Azarovitz (1982) reported weakfish and anchovies to have similar distributions.

Menhaden and other clupeid fishes (such as thread herring, alewife, and herring) were also major prey of weakfish in estuarine waters, but not in coastal waters. Welsh and Breder (1923) discussed the importance of

menhaden as a staple food of weakfish based on an unpublished manuscript by Hecht and Crozier. Other authors also reported menhaden as a major food of weakfish (Peck 1896; Smith 1907; Lascara 1981). Merriner (1975) found thread herring as the primary prey of weakfish, while menhaden ranked second. In this study, however, clupeid fish (2.2%) were not important in the weakfish's diet. Only three clupeids were identified in the results (Table 2). A possible explanation is that the distribution of clupeids have little overlap with weakfish in coastal waters, and even more likely, juvenile clupeids were more available in estuarine waters. Grosslein and Azarovitz (1982) showed menhaden to have a coastal distribution similar to weakfish, but emphasized that menhaden occurred close to shore usually inside depths of 20 m. They also showed little overlap in the distribution of blueback herring, alewife, and Atlantic herring with weakfish in coastal waters. Morris (1984) reported on the food of bluefish from the same coastal waters during 1977 through 1980 and found similar results in that clupeid fish were not a major food, even though menhaden and other clupeids are known as major food of bluefish in estuaries (Wilk 1977; Lascara 1981). Clupeid fish, particularly menhaden, were more important as food in estuarine waters than in coastal waters probably due to availability rather than feeding selectivity.

Analysis of the stomach contents indicates that weakfish are best adapted for feeding on pelagic fishes (Eigenmann 1901; Chao and Musick 1977; Lascara 1981). Pelagic feeding is reflected in their diet. Most of their prey are pelagic schooling fishes. For example, Merriner (1975) identified anchovies, thread herring, menhaden, pigfish, spot, weakfish, Atlantic croaker, kingfish, silver perch, pinfish, and butterfish as prey of weakfish. These fish are known to exhibit a polarized schooling

behavior (Hildebrand and Schroeder 1928). Silversides and alewives were other schooling baitfish readily consumed by weakfish (Peck 1896; Eigenmann 1901; Hildebrand and Schroeder 1928; Lascara 1981). Similar predation on pelagic fish occurred in coastal waters (Table 2). In the results, anchovies (24.7%), gulfstream flounder (8.6%), sand lance (4.1%), jacks (3.6%), clupeids (2.2%), round herring (1.7%), and butterfish (1.7%) were identified as the major fish prey of weakfish. With the exception of gulfstream flounder, these fish also exhibit schooling behavior. Thus, it appears that weakfish prefer schooling fish as food throughout its range.

Field and laboratory studies have shown that weakfish are pelagic predators (Eigenmann 1901; Chao and Musick 1977; Lascara 1981). Lascara (1981) observed a pelagic feeding behavior in adult weakfish. Weakfish consistently fed in the water column by visual orientation towards its prey, approached within a short striking distance (20 to 50 cm for 27-30 cm SL weakfish), and lunged forward and upward to seize its prey generally around the mid-section. Then the prey was ingested whole. Weakfish were never observed feeding on the bottom. Eigenmann (1901) also observed juveniles (ranging from 3 to 10 cm) in aquaria as entirely pelagic feeders. According to Chao and Musick (1977), weakfish are morphologically designed for feeding on pelagic organisms and not on benthic animals. They described their body design as streamlined and suitable for prolonged cruising in search of free-ranging prey (Fig. 1). The wide gaping, anterodorsally positioned mouth equipped with a band of conical teeth and two large canines is well suited for capturing large prey in the water column, however protrusible lower jaw makes feeding off the bottom difficult.

Although weakfish fed mostly on pelagic organisms, sedentary animals occassionally occurred as food. As an example, four large weakfish (58-70 cm FL) caught at one station off Long Island, New York, consumed more than 84 gulfstream flounder (C. artifrons; 40-110 mm TL). For weakfish to effectively feed on gulfstream flounder, the prey may have been swimming in the water column. Weakfish occassionally ate crabs and polychaete worms which are normally bottom-dwellers.

Crustaceans were considered secondary food for adult weakfish. Young weakfish, however, fed heavily on small crustaceans, especially mysid shrimp. Mysids were the single most important food for young weakfish having a length of 20 cm FL or less (Table 3). Numerous authors also found mysids as the primary prey of young weakfish (Hildebrand and Schroeder 1928; de Sylva et. al. 1962; Thomas 1971; Stickney et. al. 1975; Chao 1976; Schwartz et. al. 1980). Neomysis americana were identified in all studies as the predominant mysid species. Shuster (1959) even went as far as to suggest that a large portion of the weakfish production was directly or indirectly a result of their predation on crustaceans, particularly mysids. It is clear that Neomysis is a staple food of young weakfish in both coastal and estuarine waters. The preference of young weakfish for mysids may be due to prey size, abundance, and behavior. Herman (1963) reported a vertical migration behavior in mysids which may be attractive to young weakfish since Eigenmann (1901) observed young to be entirely pelagic in feeding.

It is clear that fish and mysids are major foods of weakfish, but a wide variety of other organisms were also consumed. The decapod shrimps, Crangon septemspinosus (1.5%) and Dichelopandalus leptocerus (3.9%) were significant in the diet of weakfish collected from coastal waters (Table

2). Lascara (1981) also identified Crangon as an important prey item for weakfish in the Chesapeake Bay. Dichelopandalus has not been reported as food in estuarine waters. However, Maurer and Bowman (1975) identified Dichelopandalus as the primary prey of weakfish from coastal waters during the years 1969 through 1972. They also found squid to be an important prey, but my results found squid in the diet to a lesser extent. Polychaete worms can be considered incidental prey according to my results and other authors (Smith 1907; Hildebrand and Schroeder 1928).

Most fish undergo dietary changes as they grow (Bowman and Michaels 1984). Since weakfish swallow food whole (Lascara 1981; personal observation) the size of prey should be dependent upon predator length. Stickney et. al. (1975) observed a distinctive shift in prey size for young weakfish. Weakfish between 30 and 49 mm SL fed almost entirely on copepods, while mysids became the major prey for 50-149 mm SL weakfish. Small fish eventually were the predominant food for 130-169 mm SL weakfish. Thomas (1971) also reported a similar copepod- mysid-fish shift in the diet of young weakfish. My results showed a similar dietary shift. Copepods were selected only by weakfish between 7 and 10 cm FL. Weakfish's preference for mysids dramatically changed to fish prey when they exceeded 21 cm FL (Fig. 3). Furthermore, slightly increasing lengths of fish prey were evident (Fig. 4). Welsh and Breder (1923) supported this by describing an unpublished manuscript by Hecht and Crozier. They found weakfish preference for anchovies to change to menhaden at about 35 cm and also larger weakfish selected larger menhaden. A large increase in the length of fish prey in relation to predator length was not as apparent in this study. In coastal waters, weakfish seem to prefer small fish prey, especially anchovies, as food or larger fish prey may not be as readily

available as in estuarine waters.

In temperate climates, most marine fish have adapted to seasonally fluctuating food by evolving into generalized feeders (Keast 1979). Weakfish can be classified as a generalist because of the wide range of organisms found in its diet. Weakfish not only need feeding flexibility when they seasonally migrate into different regions having different prey assemblages, but the prey may also have seasonal and annual fluctuations in distribution and abundance. The generalized feeding strategy characteristic of weakfish can be advantageous when their prey have seasonal peaks in abundance. Changes in diet of marine fishes can usually be directly correlated with the seasonal and yearly availability of prey (Bowman and Michaels 1984).

Geographic, seasonal, and annual variation existed in the stomach contents of the weakfish examined (Table 4). Although most of this variability probably can be contributed to fluctuations in prey availability, it is difficult to infer much from the data about average temporal and spatial differences in diet because of the small sample sizes. For example, mysids were important prey for juvenile weakfish, however they apparently were not available in 1980. A higher mean predator length for 1980 suggest that this apparent change in diet may be due to less juvenile weakfish in the samples since only juveniles feed on mysids (Table 6). A closer examination of the data indicated that only 3 juveniles (under 21 cm FL) occurred during 1980 while 1978 and 1979 involved 45 and 37 respectively.

Any imbalance in sampling through time and space may have also confounded the results. The results clearly showed anchovies as the primary prey of weakfish during 1978 and 1979, however none were identified in the 1980 samples (Table 5). Although the NEFC survey catch data did not indicate a decrease in the abundance of anchovies during 1980, anchovies were not as available at stations where weakfish stomachs were collected during 1980 as they were in 1978 or 1979 (Table 6). Anchovies not occurring in the 1980 samples was most likely an artifact of temporal and spatial differences in sampling.

Since weakfish are opportunistic feeders, changes in prey availability should be reflected in their diet. Although little documentation exists concerning yearly variation in abundance for most prey, especially invertebrates, dietary information can serve as a potential indicator of fluctuations in prey abundance or distribution. The results showed juvenile weakfish feeding heavily on mysids during the spring and autumn only, but mysids did not occur in the stomachs collected from south of Cape Hatteras (SCH). This is most likely a reflection of seasonal changes in the abundance and distribution of mysids, in particular with Neomysis americana. Similar seasonal and areal fluctuations in abundance and distribution were reported by Wigley and Burns (1971) who found that Neomysis were most abundant during spring and autumn and ranged in coastal waters between the Gulf of St. Lawrence and only as far south as Virginia. Although mysids did not occur in the SCH stomach contents, mysids have been reported as important food for juveniles occurring SCH in the Cape Fear estuary during the spring and summer (Stickney et. al. 1975; Schwartz et. al. 1980). Therefore, the distribution and seasonal abundance of mysids appear different between coastal and estuarine waters. We must keep in

mind that the results of this study concern only the offshore portion of the weakfish's range and that prey availability differs in the estuarine waters.

Another example of dietary variability in weakfish was the shift in preference from fish to crustaceans (70.8%) during the spring north of Cape Hatteras (NCH). Crangon shrimp (67.4%) made up the bulk of this crustacean prey. This suggests that the distribution of Crangon does not extend SCH in coastal waters and that they were readily available during the spring. Williams and Wigley (1977) reported Crangon shrimp to occur in coastal waters NCH only.

Anchovies were the major prey of weakfish in coastal waters because of similar distribution patterns. Anchovies have generally a similar migration pattern as weakfish with the exception of spring when anchovies move more inshore (Grosslein and Azarovitz 1982). Therefore, less overlap occurs in distribution between weakfish and anchovies at this time of year which was evident in the results of this paper.

Hobson (1979) described how schooling fish can effectively avoid predators during mid-day, whereas they are most vulnerable to predation at twilight. The predators which depend mainly on their vision to locate food, usually find optimum light intensity at dawn and dusk, therefore have crepuscular feeding tendencies.

Wang et.al. (1981) reported that the eye structure of Cynoscion species is specialized to see efficiently in low illumination because of a light gathering reflective layer called the retinal tapeta lucida. This enables weakfish to distinguish the prey silhouette against a twilight background from above. By positioning itself below the prey, weakfish can

stalk under the concealment of darkness.

Although the sample size is too small to reach a firm conclusion, the results suggest that weakfish fed more heavily between dusk and dawn (Fig. 5). This diurnal feeding pattern is supported by Lascara (1981) who observed weakfish in aquaria to feed most intensely during twilight and night hours. He concluded that weakfish are more successful predators at low illumination because they have a stalking strategy always approaching its prey from below and need a short striking distance of only 20-50 cm (for 27-30 cm SL fish). Popping or splashing noises were also observed at the lowest light levels as weakfish attacked prey near the surface. Although weakfish occassionally fed during daylight, a resting behavior normally occurred during this period. In the field, Lascara also found weakfish feeding in shallow eelgrass beds between dusk and dawn, and moved out of the beds into deeper water during the day. It has long been known from anecdotal observations by fishermen that weakfish are more successfully caught between dusk and dawn (Welsh and Breder 1923).

The results of this paper describe the general food habits of weakfish in coastal waters. There were apparent changes in diet by season, area, year, and time of day, but these can only be regarded in the general qualitative sense because of the sparse sampling through such a large range in time and space. We should also keep in mind that this study includes only the offshore part of the weakfish's distribution. The bulk of the population occurs in the estuarine and nearshore waters (ie. less than 6 meters). Although the results showed anchovies as the most common prey of weakfish, menhaden were reported as the more important food of weakfish in estuarine waters. Therefore, prey availability differs between the inshore and offshore range of weakfish.

A more accurate picture of the predator-prey interaction involving weakfish would require more intense sampling of stomachs both temporally and spatially, and more precise information on the geographic and depth distribution of the weakfish population. Sampling should include both the estuarine and coastal distributions of weakfish. All influencing factors must be considered to fully understand any predator-prey interrelationship. This can best be achieved by integrating survey, site-specific, and laboratory studies covering all the major factors involved.

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Table 1. Sample size and length information for weakfish stomach samples collected from each bottom trawl survey.

Vessel and Cruise No.	Date	Season and Year	Total No. of Stomachs	No. of Empty Stomachs	Fish Length FL (cm) Mean	Fish Length FL (cm) Range
DEL II 78-06	5 Sep - 22 Nov	Fall 78	112	23	22	7-75
ALB IV 79-03, DEL II 79-04	21 Mar - 12 May	Spring 79	15	6	22	14-31
ALB IV 79-08, DEL II 79-07	29 Jul - 31 Aug	Summer 79	48	16	33	22-67
DEL II 79-10	18 Sep - 9 Nov	Fall 79	126	8	29	9-73
ALB IV 80-03, DEL II 80-02	16 Mar - 8 May	Spring 80	22	6	34	23-42
ALB IV 80-08, DEL II 80-05	11 Jul - 18 Aug	Summer 80	11	7	26	15-36
DEL II 80-07	17 Sep - 14 Nov	Fall 80	25	9	42	19-72

Table 2. Listing of prey identified in the stomach contents of weakfish, *Cynoscion regalis*.

Stomach Contents	Weight (g)		Number of Organisms		Percentage Weight	
TREMATODA	0.001		2		<0.1	
NEMATODA	0.004		38		<0.1	
POLYCHAETA	13.897		221		1.1	
Prionospio plumosa		0.537		218		<0.1
Unidentified Spionidae		0.166		---		<0.1
Glycera dibranchiata		0.052		1		<0.1
Glyceria sp.		0.013		1		<0.1
Lumbrineredae		8.226		---		0.6
Onuphidae		0.517		---		<0.1
Unidentified Polychaeta		4.386		1		0.4
CRUSTACEA	191.701		14080		15.0	
Amphipoda		2.527		108		0.2
Ampelisca vadorum		0.008		2		<0.1
Ampelisca sp.		0.077		6		<0.1
Batea catherinensis		0.001		1		<0.1
Unciola irrorata		0.011		3		<0.1
Gammarus annulatus		1.035		35		0.1
Gammarus lawrencianus		1.356		56		0.1
Melita sp.		0.001		---		<0.1
Lysianassidae		0.010		2		<0.1
Paraphoxus spinosus		0.001		1		<0.1
Tironidae		0.001		1		<0.1
Unidentified Amphipoda		0.026		---		<0.1
Decapoda		142.055		271		11.1
Callianassa atlantica		1.988		32		0.2
Cancer irroratus		2.013		2		0.2
Crangon septemspinosus		18.923		212		1.5
Hippolytidae		0.007		2		<0.1
Caridion gordoni		0.240		14		<0.1
Caridion sp.		0.045		2		<0.1
Latreutes sp.		0.004		1		<0.1
Lithodidae		0.013		6		<0.1
Palaemonidae		0.011		642		<0.1
Dichelopandalus leptocerus		49.902		180		3.9
Pasiphaeidae		0.407		14		<0.1
Parapeneus longirostris		0.500		10		<0.1
Unidentified Penaeidae		0.569		7		<0.1
Ovalipes ocellatus		56.551		17		4.4
Lucifer faxoni		0.002		1		<0.1
Acetes carolinae		4.938		321		0.4
Acetes sp.		0.177		12		<0.1
Processa bermudensis		0.019		1		<0.1
Decapoda larvae		0.062		55		<0.1
Hermit crab unidentified		0.657		2		0.1
Shrimp unidentified		0.178		5		<0.1
Unidentified Decapoda		4.849		17		0.4
Isopoda		0.537		8		<0.1
Cirolana sp.		0.526		6		<0.1
Edotea triloba		0.010		1		<0.1
Unidentified Isopoda		0.001		1		<0.1
Mysidacea		43.470		13019		3.4
Mysidopsis bigelowi		9.078		4960		0.7
Mysis mixta		0.003		1		<0.1
Neomysis americana		32.660		8054		2.6
Unidentified Mysidacea		1.729		4		0.1
Copepoda		0.003		15		<0.1
Calanus sp.		0.002		13		<0.1
Centropages sp.		0.001		2		<0.1
Stomatopoda		2.468		5		0.2
Squilla empusa		0.262		1		<0.1
Unidentified Stomatopoda		2.206		4		0.2
Crustacea larvae		0.004		2		<0.1
Unidentified Crustacea		0.637		10		0.1
MOLLUSCA	112.463		7		8.8	
Pelecypoda		1.309		1		0.1
Sdenidae		1.306		1		0.1
Unidentified Pelecypoda		0.003		---		<0.1
Cephalopoda		111.154		6		8.7
Loligo sp.		69.190		3		5.4
Illex illecebrosus		39.176		1		3.1
Unidentified Cepholopoda		2.788		2		0.2

Table 2. (Continued)

Stomach Contents	Weight (g)		Number of Organisms		Percentage Weight	
PISCES	960.962		360		74.8	
Etrumeus teres		21.239		2		1.7
Clupeidae		28.525		3		2.2
Anchoa hepsetus		36.333		17		2.8
Anchoa mitchilli		260.866		139		20.3
Anchoa sp.		8.456		3		0.7
Unidentified Engraulidae		11.023		13		0.9
Gadus morhua		0.367		1		<0.1
Hake unidentified		16.717		7		1.3
Myctophidae		8.590		---		0.7
Ammodytes americana		52.106		10		4.1
Caranx hippos		31.040		1		2.4
Carangidae		14.947		1		1.2
Cynoscion regalis		14.591		1		1.1
Peprilus triacanthus		22.192		4		1.7
Macrozoarces americanus		1.598		1		0.1
Citharichthys arctifrons		110.729		64		8.6
Bothidae		20.527		1		1.6
Pleuronectiformes		0.033		2		<0.1
Aluterus scriptus		5.642		22		0.4
Fish bones		0.036		---		<0.1
Fish scales		0.066		---		<0.1
Fish larvae		1.263		37		0.1
Fish unidentified		294.076		31		22.9
ANIMAL REMAINS	4.497		---		0.3	
PLANT REMAINS	0.547		---		<0.1	
TOTAL	1284.072		14708		100.0	

Number of stomachs examined	359
Number of empty stomachs	75
Mean stomach content weight (g)	3.577
Mean fish FL (cm)	27.7

Table 3. Prey composition expressed as a percentage of the total stomach contents weight for each 10 cm length interval of weakfish, *Cynoscion regalis*.

Stomach Contents	Length Category (cm)										
	1-10		11-20		21-30		31-40		41-50		
POLYCHAETA	------		1.4		0.6		-----		<0.1		
CRUSTACEA	100.0		78.5		12.2		6.2		18.2		
Amphipoda	-----		0.3		<0.1		0.6		1.7		
Mysidacea	89.0		64.0		6.1		3.3		15.6		
Neomysis americana		43.6		43.		3.1		3.3			15.5
Mysidopsis bigelowi		18.3		12.2		3.0		----			<0.1
Other Mysidacea		27.1		8.8		----		----			-----
Stomatopoda	-----		<0.1		0.2		----		-----		
Decapoda	10.6		13.9		5.7		2.2		0.9		
Dichelopandalus leptocerus		-----		-----		0.8		----			----
Crangon septemspinosus		2.0		2.2		0.5		1.1			0.3
Other decapod shrimp		8.1		8.0		3.1		1.0			<0.1
Ovalipes ocellatus		----		----		0.1		----			----
Other decapod crab		----		<0.1		----		<0.1			0.2
Other Decapoda		0.5		3.7		1.2		0.1			0.4
Other Crustacea	0.4		0.2		0.2		0.1		<0.1		
MOLLUSCA	-----		-----		9.8		<0.1		0.8		
Cephalopoda	-----		----		9.2		<0.1		0.8		
Loligo sp.		----		-----		----		----			----
Illex illecebrosus		----		-----		8.7		----			----
Other Cephalopoda		----		-----		0.5		<0.1			0.8
Other Mollusca	----		----		0.6		----		----		
PISCES	-----		19.7		77.2		93.7		81.0		
Anchoa mitchilli		----		-----		6.3		12.9			79.9
Anchoa hepsetus		----		-----		15.2		1.5			-----
Other Engraulidae		----		7.6		4.2		2.4			-----
Citharichthys arctifrons		----		-----		----		----			-----
Other Pleuronectiformes		----		-----		<0.1		----			-----
Ammodytes americanus		----		-----		----		----			-----
Caranx hippos		----		-----		----		21.3			-----
Other Carangidae		----		-----		6.7		-----			-----
Etrumeus teres		----		-----		3.0		-----			
Other Clupeidae		----		-----		12.7		-----			-----
Peprilus triacanthus		----		-----		0.2		-----			-----
Urophycis sp.		----		-----		-----		-----			-----
Cynoscion regalis		----		-----		-----		10.0			-----
Fish larvae		----		4.0		0.2		-----			-----
Other Pisces		----		8.1		28.7		45.6			1.1
MISCELLANEOUS	-----		0.4		0.2		0.1		<0.1		
Number of stomachs examined	13		72		189		41		15		
Number of empty stomachs	1		10		54		8		0		
Mean stomach content weight (g)	0.050		0.252		1.233		3.562		5.506		
Mean fish FL (cm)	9		15		26		34		45		

Table 3. (Continued)

Stomach Contents	Length Category (cm)					
	51-60		61-70		71-80	
POLYCHAETA	3.3		-----		-----	
CRUSTACEA	15.4		10.6		14.0	
Amphipoda		<0.1		----		----
Mysidacea		----		----		----
Neomysis americana		----		----		----
Mysidopsis bigelowi		----		----		----
Other Mysidacea		----		----		----
Stomatopoda		-----		-----		0.7
Decapoda		15.3		10.6		13.3
Dichelopandalus leptocerus		11.9		0.1		0.6
Crangon septemspinosus		2.8		1.9		----
Other decapod shrimp		-----		-----		0.1
Ovalipes ocellatus		0.6		7.9		12.0
Other decapod crab		-----		0.7		-----
Other Decapoda		-----		-----		0.6
Other Crustacea		0.1		<0.1		-----
MOLLUSCA	0.7		0.4		25.3	
Cephalopoda		0.7		0.4		25.3
Loligo sp.		-----		-----		25.3
Illex illecebrosus		-----		-----		-----
Other Cephalopoda		0.7		0.4		-----
Other Mollusca		-----		-----		-----
PISCES	80.3		87.8		60.7	
Anchoa mitchilli		9.4		7.5		39.6
Anchoa hepsetus		-----		-----		-----
Other Engraulidae		-----		1.3		-----
Citharichthys arctifrons		2.0		51.5		-----
Other Pleuronectiformes		-----		-----		7.5
Ammodytes americanus		13.8		0.2		-----
Caranx hippos		-----		-----		-----
Other Carangidae		-----		-----		-----
Etrumeus teres		-----		5.4		-----
Other Clupeidae		-----		-----		-----
Peprilus triacanthus		-----		5.4		2.6
Urophycis sp.		-----		6.2		-----
Cynoscion regalis		-----		-----		-----
Fish larvae		-----		-----		-----
Other Pisces		55.1		10.3		11.0
MISCELLANEOUS	0.3		1.2		-----	
Number of stomachs examined	15		11		3	
Number of empty stomachs	0		2		0	
Mean stomach content weight (g)	25.086		24.468		91.206	
Mean fish FL (cm)	54		67		73	

Table 4. Composition of the stomach contents, expressed as a percentage of the total stomach content weight, by area and season for weakfish (*Cynoscion regalis*).

Stomach Contents	South of Cape Hatteras					
	Spring		Summer		Fall	
POLYCHAETA	-----		-----		0.6	
CRUSTACEA	4.2		3.9		14.2	
Amphipoda		0.1		-----		0.1
Mysidacea		<0.1		-----		<0.1
Neomysis americana		-----		-----		-----
Mysidopsis bigelowi		-----		-----		<0.1
Other Mysidacea		<0.1		-----		<0.1
Stomatopoda		----		-----		0.3
Decapoda		4.1		3.9		13.7
Dichelopandalus leptocerus		-----		1.9		-----
Crangon septemspinosus		-----		-----		-----
Other decapod shrimp		2.4		0.7		12.2
Ovalipes ocellatus		-----		-----		0.5
Other decapod crab		0.4		-----		-----
Other Decapoda		1.3		1.3		1.0
Other Crustacea		<0.1		-----		0.1
MOLLUSCA	0.1		20.9		-----	
Cephalopoda		0.1		20.9		-----
Loligo sp.		-----		-----		-----
Illex illecebrosus		-----		20.9		-----
Other Cephalopoda		0.1		-----		-----
Other Mollusca		----		-----		-----
PISCES	95.7		75.2		84.9	
Anchoa mitchilli		4.0		-----		21.5
Anchoa hepsetus		-----		33.7		-----
Other Engraulidae		-----		-----		15.2
Citharichthys arctifrons		-----		-----		-----
Other Pleuronectiformes		-----		-----		-----
Ammodytes americanus		-----		-----		-----
Caranx hippos		-----		-----		-----
Other Carangidae		-----		15.9		-----
Etrumeus teres		-----		-----		-----
Other Clupeidae		-----		-----		21.5
Peprilus triacanthus		0.3		-----		-----
Urophycis sp.		-----		-----		-----
Cynoscion regalis		-----		-----		-----
Unidentified fish larvae		-----		-----		1.6
Other Pisces		91.4		25.6		25.1
MISCELANEOUS	-----		<0.1		0.3	
Number of stomachs examined	20		26		58	
Number of empty stomachs	4		5		12	
Mean stomach content weight (g)	2.214		3.608		0.760	
Mean fish FL (cm)	31		28		25	

Table 4. (Continued)

Stomach Contents	North of Cape Hatteras					
	Spring		Summer		Fall	
POLYCHAETA	-----		-----		0.1	
CRUSTACEA	70.8		1.0		15.1	
Amphipoda		-----		----		0.2
Mysidacea		2.3		----		3.7
Neomysis americana		2.1		-----		2.8
Mysidopsis bigelowi		0.2		-----		0.8
Other Mysidacea		-----		-----		0.1
Stomatopoda		-----		----		0.2
Decapoda		67.4		1.0		10.9
Dichelopandalus leptocerus		-----		-----		4.0
Crangon septemspinosus		67.4		0.9		1.5
Other decapod shrimp		-----		-----		0.2
Ovalipes ocellatus		-----		-----		4.8
Other decapod crab		-----		-----		0.2
Other Decapoda		-----		0.1		0.2
Other Crustacea		1.1		----		0.1
MOLLUSCA	-----		11.6		6.3	
Cephalopoda		-----		5.1		6.3
Loligo sp.		-----		-----		5.9
Illex illecebrosus		-----		-----		-----
Other Cephalopoda		-----		5.1		0.4
Other Mollusca		-----		6.5		-----
PISCES	28.8		86.5		78.1	
Anchoa mitchilli		-----		-----		21.4
Anchoa hepsetus		-----		23.8		-----
Other Engraulidae		-----		-----		1.0
Citharichthys arctifrons		-----		-----		12.5
Other Pleuronectiformes		-----		-----		1.8
Ammodytes americanus		-----		-----		4.4
Caranx hippos		-----		-----		2.7
Other Carangidae		-----		-----		-----
Etrumeus teres		-----		33.5		1.2
Other Clupeidae		-----		-----		1.6
Peprilus triacanthus		-----		1.5		1.9
Urophycis sp.		-----		-----		1.4
Cynoscion regalis		-----		-----		1.2
Unidentified fish larvae		-----		-----		<0.1
Other Pisces		28.8		27.7		27.0
MISCELLANEOUS	0.4		0.9		0.4	
Number of stomachs examined	17		33		205	
Number of empty stomachs	8		18		28	
Mean stomach content weight (g)	0.092		0.608		5.778	
Mean fish FL (cm)	27		28		28	

Table 5. Composition of the stomach contents, expressed as a percentage of the total stomach contents weight, by year for weakfish (*Cynoscion regalis*).

Stomach Contents	1978		1979		1980	
POLYCHAETA	1.7		<0.1		3.3	
CRUSTACEA	39.7		10.7		18.4	
Amphipoda		0.1		0.1		0.4
Mysidacea		33.4		2.5		----
Neomysis americana		20.6		2.4		----
Mysidopsis bigelowi		11.4		<0.1		----
Other Mysidacea		1.4		0.1		----
Stomatopoda		0.4		0.3		----
Decapoda		5.6		7.6		18.0
Dichelopandalus leptocerus		-----		0.2		12.2
Crangon septemspinosus		1.5		1.1		2.1
Other decapod shrimp		2.9		0.7		0.3
Ovalipes ocellatus		<0.1		5.5		2.2
Other decapod crab		-----		-----		0.6
Other Decapoda		1.2		0.1		0.6
Other Crustacea		0.2		0.2		-----
MOLLUSCA	<0.1		10.7		0.5	
Cephalopoda		-----		10.6		0.5
Loligo sp.		-----		7.9		-----
Illex illecebrosus		-----		2.3		-----
Other Cephalopoda		-----		0.4		0.5
Other Mollusca		<0.1		0.1		-----
PISCES	58.4		78.0		77.8	
Anchoa mitchilli		-----		25.3		-----
Anchoa hepsetus		-----		4.1		-----
Other Engraulidae		9.7		1.1		-----
Citharichthys arctifrons		-----		-----		38.5
Other Pleuronectiformes		<0.1		-----		5.4
Ammodytes americanus		-----		6.0		-----
Caranx hippos		-----		3.6		-----
Other Carangidae		-----		1.7		-----
Etrumeus teres		-----		0.8		3.8
Other Clupeidae		-----		3.3		-----
Peprilus triacanthus		9.2		<0.1		3.9
Urophycis sp.		-----		-----		0.7
Cynoscion regalis		-----		1.7		-----
Unidentified larval fish		0.4		0.1		-----
Other Pisces		39.1		30.3		25.5
MISCELLANEOUS	0.2		0.6		-----	
Number of stomachs examined	112		189		58	
Number of empty stomachs	23		30		22	
Mean stomach content weight (g)	0.697		4.666		6.545	
Mean fish FL (cm)	22		29		36	

Table 6. Percentage weight of anchovies in the total stomach contents of weakfish compared to the mean number of anchovies occurring at the same stations that the stomach samples were collected during the years 1978, 1979, and 1980.

	1978	1979	1980
% wt. of anchovies in stomach contents	9.7	30.7	0
Mean # of anchovies per station	2200	7141	570
Number of stomachs collected	112	189	58
Mean fish length (cm FL)	22	29	36
Fish length range	7-75	9-73	15-72
Number of anchovies	28603	235674	7980
Number of stations examined	13	33	14
Number of stations without anchovies	2	6	6

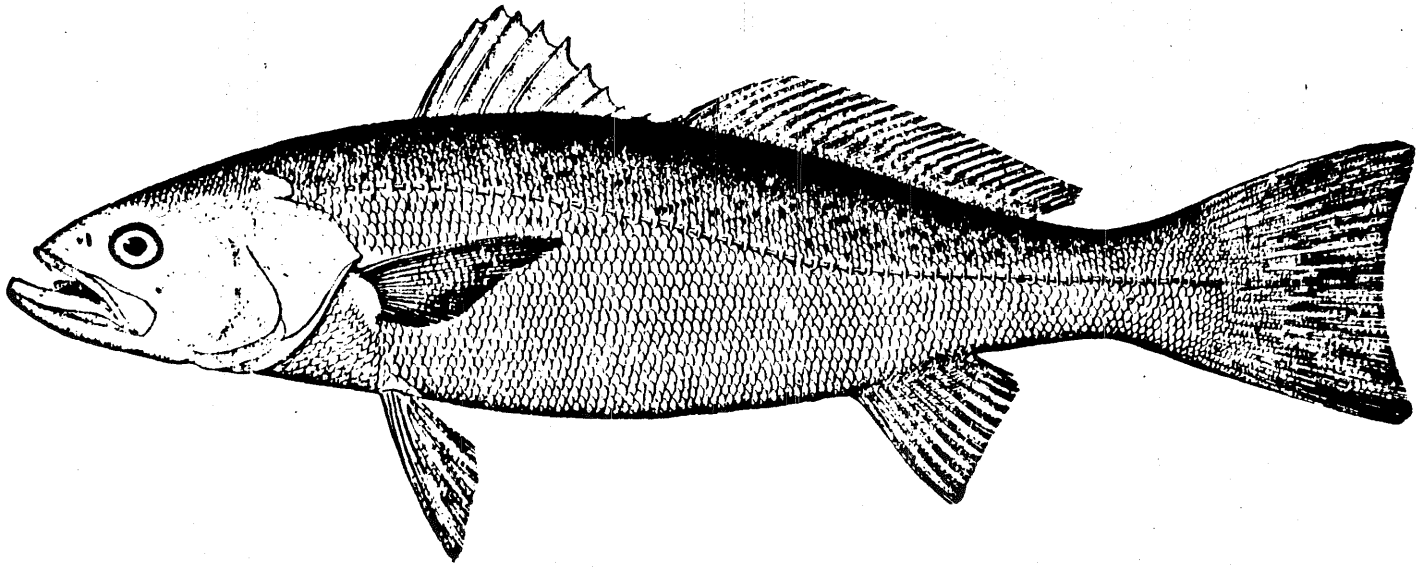

FIGURE 1. Weakfish, *Cynoscion regalis* (Bloch and Schneider), 1801 (illustration by H. L. Todd from: Goode, 1884).

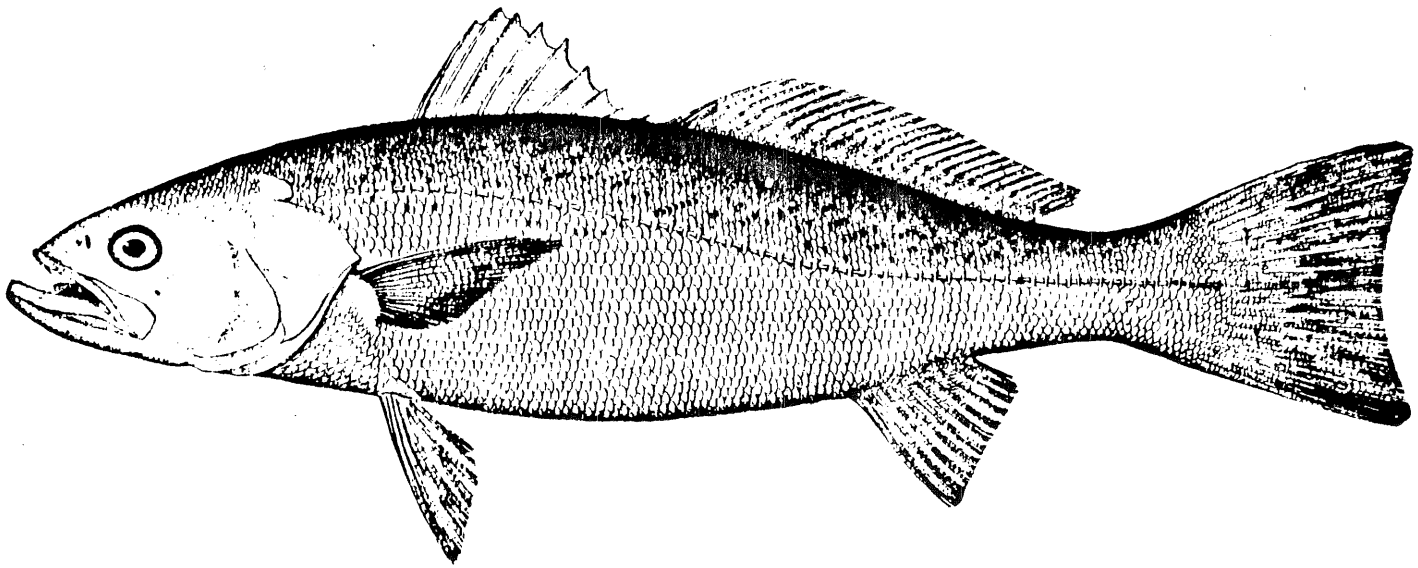

FIGURE 1. Weakfish, Cynoscion regalis (Bloch and Schneider), 1801 (illustration by H. L. Todd from: Goode, 1884).

Figure 2. Stations where weakfish occurred during the Northeast Fisheries Center bottom trawl surveys in the spring, summer, and fall of 1978, 1979, and 1980. The study area includes the coastal waters (having depths greater or equal to 6 meters) between Cape Cod, Massachusetts and Cape Fear, North Carolina.

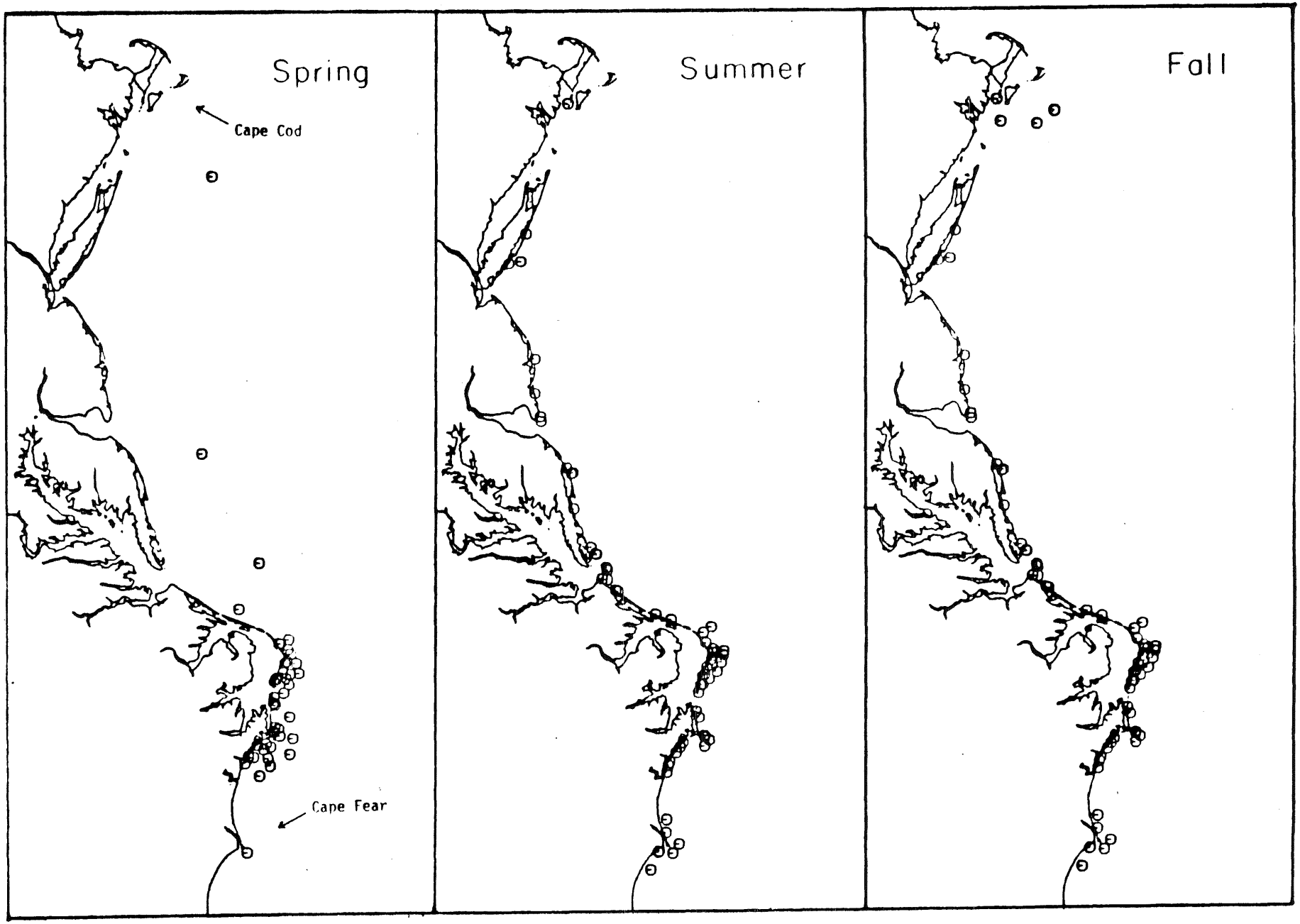

Figure 3. The dietary change from mysid shrimp to fish prey by 10 cm length (FL) categories for weakfish, Cynoscion regalis. Food is expressed as percentage weight of the total stomach contents.

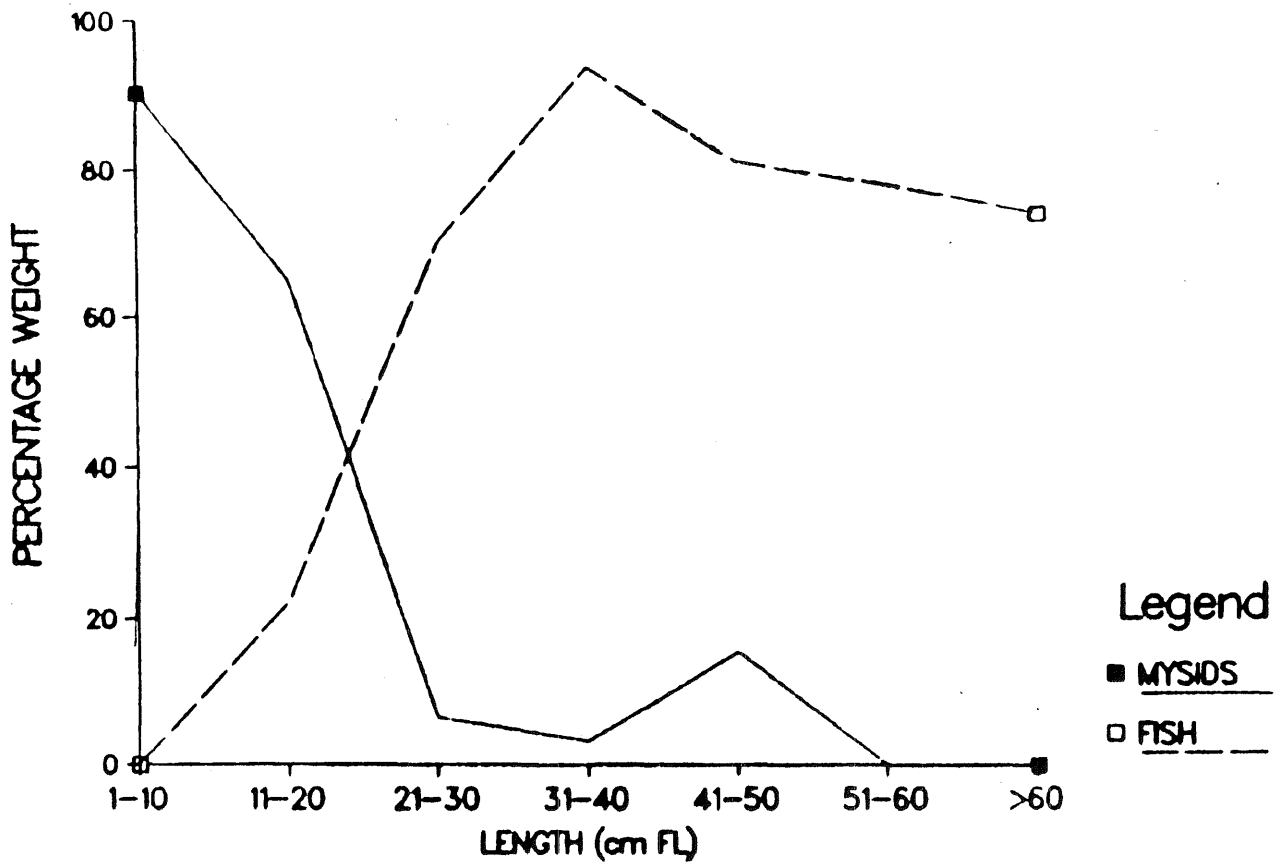

Figure 4. Mean and range of the fish prey length (mm TL) for each 10 cm length (FL) category of weakfish, Cynoscion regalis.

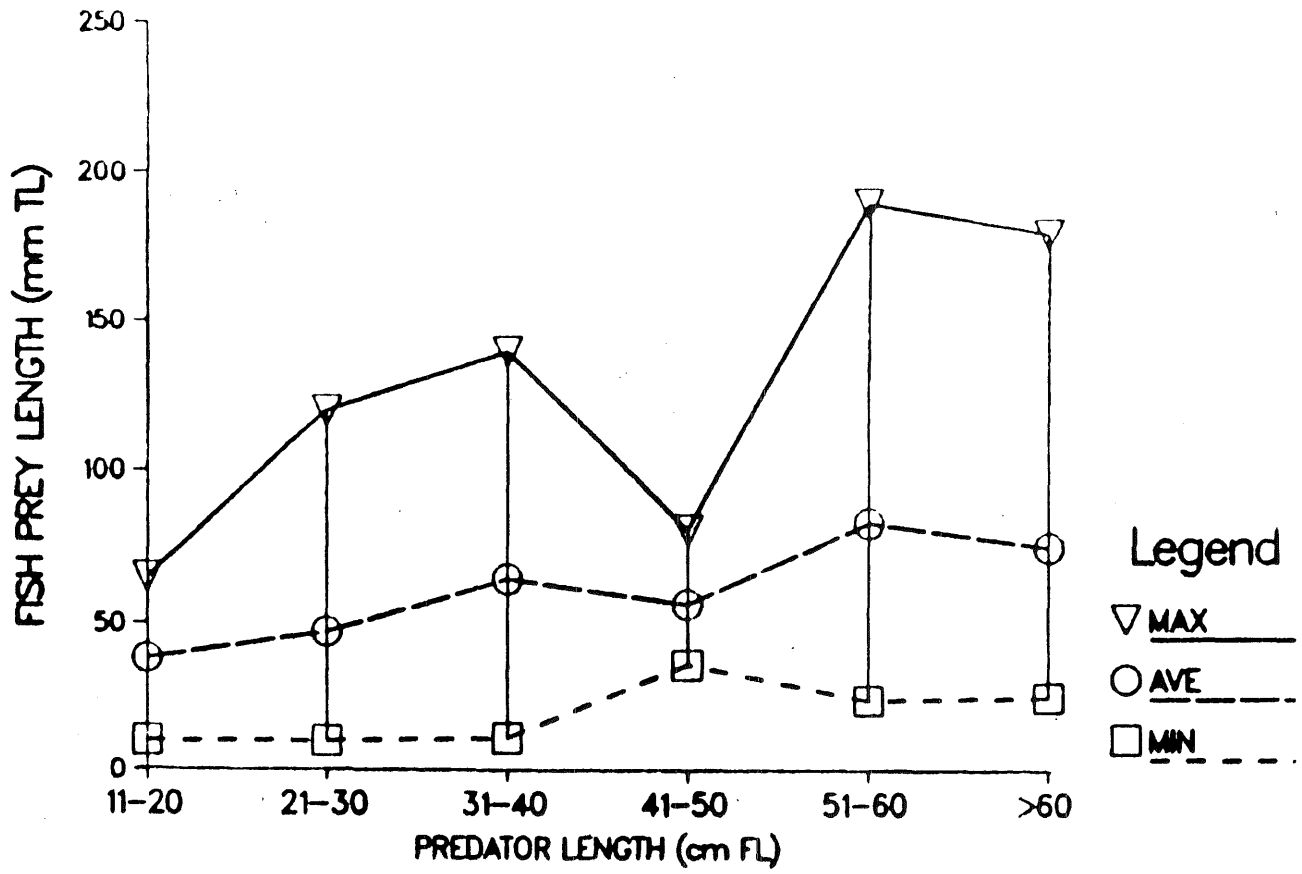
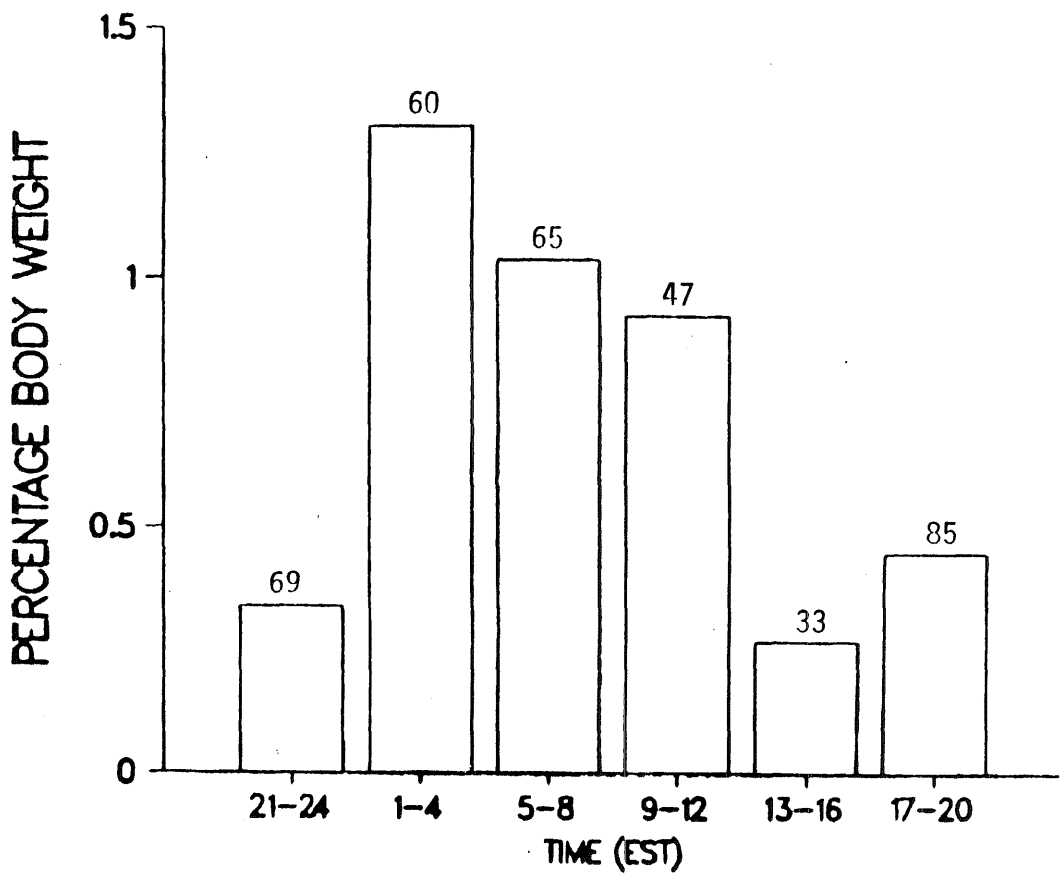
Figure 5. Percentage body weight of stomach contents versus time of day for weakfish, *Cynoscion regalis*. Number of fish are indicated above the bars.